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42. **Smidt, Ferd.**, Eine neue Species des Genus Graffilla (v. Ihering). Sitz. Ber. Nat. Ges. Dorpat. 8, 1887.

43. **Strassen, O. zur**, Ueber *Filaria rigida*, Vorlaüf. Mittheil. Zool. Anz. 14, 1891 (p. 437.)

44. **Topsent**, (1887.)

45. **Van Beneden, P. J.**, Sur les organes sexuels des Huitres (O. edulis). Compt. rend. Acad. Sci. Paris, XL.

46. **Wheeler, W. M.**, Protandric Hermaphroditism in Myzostoma. Zool. Anz. XVII, 1894.

47. **Wiren, A.**, Studien über die *Solenogastren*, II. Kongl. Svenska Vetensk. Akad. Handl. 25, 1892.

48. **Zschokke, F.**, Studien über den anatomischen und histologischen Bau der Cestoden. Centralbl. f. Bakter. und Parasitk. 1, 1887 (p. 337, 409.)

SPONGES: RECENT AND FOSSIL.

By Joseph F. James, M. D., M. Sc., U. S. Dept. Agriculture, Washington, D. C.

A sponge, while one of the lowest forms in the scale of animal existence, belongs to a class ranging back in time almost to the beginning of organized life. As known in a living state it is an aggregation of individuals, each one minute, but together forming a body often of considerable size. Without power of locomotion; without any differentiation of parts such as obtain in animals of a higher grade, it yet manages to subsist in a great number of places and in the greatest variety of forms. Geology tells us the family has persisted upon the earth since the earliest time of which there is any record; and at no period has it been absent from places suited for the growth of its various members. A few words about living sponges may make plainer a short account of some of the fossil forms.

The modern sponge is most familiar as an article of toilet use, varying in size from one as small as an egg to one that would fill a half-bushel basket; and differing in texture as much as in size. The gathering of this sort of sponge is a distinct trade, pursued by fishermen in many quarters of the globe, but especially in the Mediterranean. The value of the fisheries for a single year (1871), as represented at a single port (Trieste), was over half a million dollars ($540,000).

The examination of one of these sponges of commerce shows a porous structure, with a vast number of holes, some large, some small. The large ones are called "oscula." This porous body is but the skeleton, the animal matter, a sticky, gelatinous mass, having been destroyed in preparing the sponge for commercial purposes. If one of these aggregations of animalcules be studied in a living state, an interesting sight is visible.

A stream of water enters the smaller pores, is carrried by the branching canals through the interior, and is ejected from the larger openings or oscula. (Fig. 1.) The ingoing streams carry with them the food of the colony; the outgoing ones take away the waste or insoluble particles, and the water cleared of the food suitable for the growth of the individuals among which it has passed. The water is drawn into the sponge mass by the action of rapidly vibrating cilia or hairs, and it is forced out by the constant inflow thus created.

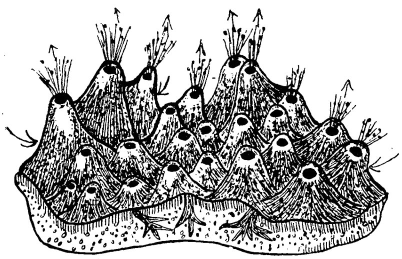

Fig 1. Portion of sponge, highly magnified, showing incurrent and excurrent streams. The arrows indicate the direction of the water. (After T. Rymer Jones.)

A close examination of the skeleton shows it to be made up of multitudes of fibres, sometimes calcareous, sometimes siliceous. In most instances siliceous spicules are found in great abundance, though these are, in certain forms, calcareous. The spicules are most diversified in form. Some are long, straight and bar-like, pointed at one or both ends or else club-shaped; some are provided with three, four, six or many branches; sometimes spines are produced, at the tips or on the sides;

sometimes there are developed at the top or bottom, cross-bars, or there is a cluster, curving upward or downward; some are shaped like harpoons, with spines along the sides, all pointing in one direction. Some are curved; some have an umbrella-like top; some are oval, star-shaped, or are developed in the form of a rosette (Fig. 2). Sometimes these spicules are simply scattered promiscuously through the fibrous net-work; but in other instances they become united during growth at their free ends, and a network is formed from which results such species as the beautiful Venus's Flower Basket sponge.

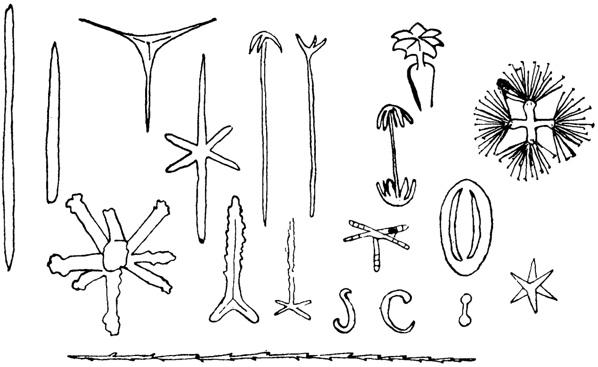

FIG. 2. Various forms of sponge spicules. (After Sollas).

Each one of the spicules of a sponge originates in a single cell, within which it remains until fully grown. "During its growth the spicule slowly passes from the interior to the exterior of the sponge, and is finally (at least in some species) cast out as an effete product. The sponge is thus constantly producing and disengaging spicules; and in this way we may account for the extraordinary profusion of these structures in some modern marine deposits and in the ancient stratified rocks." (W. J. Sollas).

While the sponge as a mass does not show any differentiation into special parts or organs, there are frequently scattered throughout its tissues certain wandering amœboid cells. These seem to perform special purposes. Some act as scavengers; others as carries of nourishment; while some become converted into sexual products. It is even supposed from the connection of certain cells by ganglia with groups of other cells, that there may be a few nerve fibres, with the power of converting external impressions into muscular movements.

The life history of sponges is, as yet, imperfectly known. Our knowledge can be given in a comparatively few words. Increase takes place by internal and external budding; by fission (division); and by sexual reproduction. In the method of increase by budding, a few cells become developed at some point, increase by general growth, bulge out from the cortex, and drop off to form a new colony. In internal division a mass of cells forms a globular cluster. The outer ones change so as to form an external sac. Under certain conditions the cells from the interior creep out from the enclosing sac, form a spreading mass, and give rise to a new colony. Sollas supposes these "gemmules" serve a protective purpose, and insure the persistence of the race, "since," says he, "they only appear in extreme climates on the approach of drought, and in cold ones on the approach of winter. As a secondary function they serve for the dispersal of the species; some are light enough to float down a stream, but not too far, so that there is no danger of their being carried to sea; others which are characterized by large air chambers, are possibly distributed by the wind."

Both sexes may occur in the same colony—though frequently one predominates—or they may be entirely separated. The ovum or female form develops from one of the wandering cells previously referred to, gradually increasing in size and finally passing into a resting state. The spermatozoan or male element is a minute oval or pear-shaped body with a long vibratile tail. The tailed bodies are also developed from wandering amœboid cells, each cell containing numbers of them. When mature, the spermatozoa rupture the walls of the sac where they are confined, and at a favorable opportunity enter and fertilize the ovum. After this occurs the egg begins to grow, the cells at either end assuming distinct characters. When mature, the new individual ruptures the cell wall, enters one of the canals ramifying throughout the sponge body, and is carried out through the oscula by the out-flowing current, swimming and whirling about in a lively manner. It soon assumes a more spherical form, while a depression appearing at one end increases in depth until a cup-shaped cavity results. The young spore then settles on a rock or some other substance, mouth downwards, becoming fast to its future abiding place. It elongates and becomes a cylindrical larva; the depression at the upper end develops into an opening or osculum, and the last stage of growth of the sponge is entered upon. It has now simply to divide and increase in size to form the sponge as we know it. The process varies, of course, with different species, but the stages of egg, free swimming larva, attached larva and developed sponge are the same in all.

It is, of course, impossible to say that fossil species of sponges passed through the cycle which has been briefly described, although there is every reason to believe it to have been so. But of one thing we are certain, that in the sponges we have a group of organisms which has persisted under a great variety of forms through all the vicissitudes of the earth's career. Thousands of kinds have ceased to exist; hundreds have been preserved to us in the rocks of various formations. Yet with all the extinction that has occurred, there is not a single large group which has not both fossil and living representatives. It is, therefore, a most interesting group of organisms, and one which neither time nor changeed conditions has caused to disappear.

The oldest known series of fossil-bearing rocks in the world contains forms which belong to the sponges. Like low types that live at present, these early sponges were widely dispersed over the earth, and the same species occurs in rocks of Lower Cambrian age in Labrador on the eastern and in Nevada on the western side of the continent. One of the genera that seems to combine the features of the two great groups of corals and sponges, and whose position is, in consequence, still a matter of discussion, is known as *Ethmophyllum.* The species are simple, elongated, cup-shaped, turbinate or club-shaped; they may be curved or straight; ribbed, lobed or corrugated.

A thin membrane lines the inner and covers the outer wall, pierced by a great number of holes, while the two tissues are united by a number of septa. Dr. Dawson compares it to an

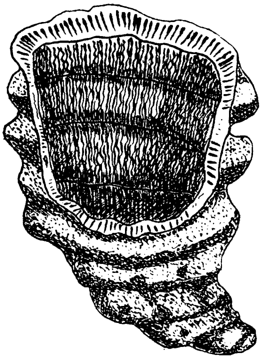

FIG. 3. *Ethmophyllum*, partly restored. (After Billings.)

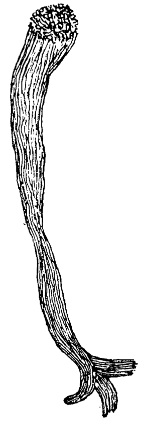

FIG. 4. *Leptomitus.* (After Walcott.)

inverted cone, formed of carbonate of lime, with its point imbedded in the mud and the open cup above (Fig. 3). The lower part is composed of thick plates, enclosing communicating chambers. The cup expands above and the spaces between the two membranes are filled with sarcode or animal matter. Out from the pores projected innumerable pseudopodia, that served to convey food to the colony.

Another one of the sponges from the Lower Cambrian horizon is a member of the group to which the Glass-rope sponge belongs, and it seems to be almost the earliest progenitor of the group. It has been named *Leptomitus* (Fig 4) and consists of a long bundle of acicular threads. It represents, possibly, the anchoring body of a sponge similar to *Hyalonema* found at present in the eastern seas. In *Protospongia* is an example of a form with a very wide geographical range. It has been found in Cambrian rocks in England, in Norway and Sweden, in New Brunswick and in Nevada. The extension of this species over so wide an area is indicative of great similarity of conditions in widely separated countries. It indicates a similarity in temperature, similar conditions of sedimentation, similar oceanic currents, and probably similar depths of water.

As time passes and we ascend the geological scale, the number and variety of genera of sponges increases. In rocks of Trenton age there has been found in a few localities in Kentucky, a form known as *Brachiospongia* (Fig. 5). It has a large, cup-shaped body, with an open, central cavity, and with from seven to thirteen arms radiating from it. No perfect specimen of this has ever been found, and the conditions of preservation have not been such as to favor the presence of the minuter features. The probabilities are that it grew on the ocean floor, fastened by a single point, with the open mouth of the cup above, and the so-called arms extending out in all directions. Its cruciform spicules ally it to certain modern living forms.

In rocks of later age occur interesting cylindrical or turbinate forms described originally as sea-weeds. The framework is in the form of a net with regular meshes, the threads crossing each other at right angles. Professor Whitfield says that the threads "are not interwoven with each other like basket work, or like the fibres of cloth, nor do they unite with each other as do vegetable substances; but one set appears to pass on the outside, and the other on the inside of the body. The threads composing the network vary in strength, and are in regular sets in both directions."

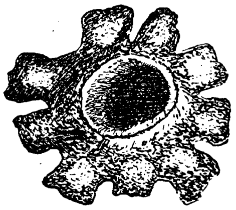

FIG. 5. *Brachiospongia;* reduced. (After Marsh).

One of the species of this family, known as *Cyathophycus*, occurs in clusters in the Utica slate rocks of New York. It is almost the earliest representative of a group that, in Devonian time, assumed a great development, and appeared in many different forms. The family is known as *Dictyospongidæ*, and presents an interesting instance of the beginning, the culmination and the dying out of a family of organisms. Beginning with the simple sac-shaped *Cyathophycus* (Fig. 6), or the globular *Rhombodictyon* in the Utica slate, it branched off into prismatic, nodulose (Fig. 7) or spinose *Dictyophytons* in the

Devonian, and died out in large, simple or rugose species in the lower Carboniferous age.

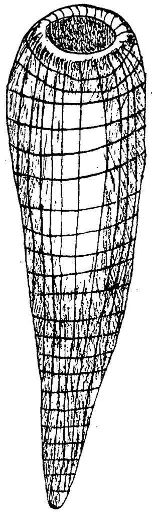

FIG. 6. *Cyathophycus.* (After Hall.)

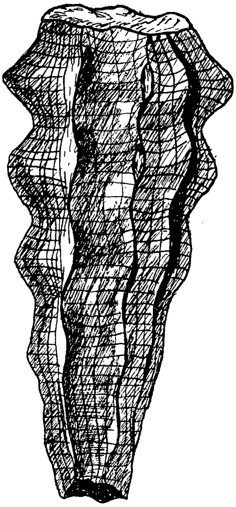

FIG. 7. *Dictyophyton.* (After Hall)

A variety of sponges occur in deposits of Niagara age in various parts of the world. Among these are some peculiar globular and basin-shaped forms that have been found in deposits in Tennessee, in Ohio and in Gotland. They are known as *Astylospongia,* and were free-growing and unattached. The spiculæ are star-shaped and united by their extremities into a compact whole.

One of the most interesting modern discoveries relating to fossil sponges is that showing the flint nodules so common in all deposits of Cretaceous age, to be formed largely of sponge spicules. Not only is this so, but extensive deposits of chert of Permian and Carboniferous age, have likewise been shown to be made up largely of these bodies. A remarkable paper by Dr. G. J. Hinde, describes the contents of a hollow flint, about a foot in diameter, from near Norwich, England. He gives details of finding, in about three or four ounces of dried " flint meal " from this flint, many hundreds of sponge spicules, together with remains of other organisms. Some of the objects were so completely changed to silica, that acid had no effect upon them; while others were so entirely composed of carbonate of lime as to be dissolved. Dr. Hinde describes and figures the spicules, and says that no less than one hundred and sixty forms were observed. These he classified into thirty-eight species of thirty-two genera. Some doubt may be expressed as to the validity of these genera and species, but that the spicules occur at all is sufficient evidence of the part the sponges played in the great formations, and indicates their abundance at certain periods in the past.

Modern deep-sea dredgings have shown that sponges exist now in wonderful profusion. In the Indian Ocean, out of about a quart measure of material, no less than sixty-two species of sponges were described. Dr. Hinde in discussing the relations between the habitats of modern and fossil sponges, notes the different depths at which various Atlantic species occur. Some of these are nearly related by their spicules to forms occurring in the flint nodule; and the conclusion is reached that the species there represented could have lived in water varying from 1 to 1700 feet deep. The resemblance between the spicules found in Dr. Hinde's flint, and those occurring in nodules in Ireland, Westphalia and Belgium; and in strata varying from Cretaceous to Eocene Tertiary, indicate an extensive distribution both in space and in time.

The importance of the statement of Sollas that spicules are being continually given off by the sponge in its process of growth is seen when it becomes known that thick beds of sediment are largely formed of these bodies. It at once reduces the number of individuals which it is necessary to imagine, if these strata are formed of the effete products, rather than of the remains of individual sponges.

Two interesting facts may be noted in conclusion, relative to this group of organisms. One is the great variability it presents. Professor Alexander Agassiz says (Three Cruises of the Blake, vol. 2, p. 170) that with the group all our ideas of species are completely upset. " It seems as if in the sponges we had a mass in which the different parts might be considered as organs capable in themselves of a certain amount of independence, yet subject to a general subordination, so that, according to Haeckel and Schmidt, we are dealing neither with individuals nor colonies in the ordinary sense of the words." He then quotes Schmidt as saying that "in place of an individual, or a colony, we find an organic mass, differentiated into organs, while the body, which feeds itself and propagates, is neither an individual nor a colony." It would thus appear that the long existence of the group has not tended to the fixation of characters, and it is probable that the tendency to variation now manifest, was just as marked in early geological time.

The other point is of interest to evolutionists. Sollas points out that the same type of canal system exists in genera of three distinct and apparently unrelated families. Further, that the development of a cortex has taken place independently, though on parallel lines, in several other distinct families. Finally, that while calcareous and siliceous spicules have had an independent origin, yet the forms of the one are repeated by the forms of the other. He comes to the conclusion that variation does not depend upon accident, "but on the operation of physical laws as mechanical in their action here as in the mineral world." If, further, he continues, "the independent evolution of similar structures is of such certain and quite common occurrence in the case of the sponges, it is also to be looked for in other groups." Thus, a multiple origin of species, instead of being an improbability, is about as likely to occur as a single origin. Identically the same variety could scarcely arise in two isolated localities, but forms now supposed to be genetically related, may have been of distinct origin.